1.8 Cellular Overlay Capability

When a CDMA system overlays a FDMA system, the interference to the FDMA user at the base can be estimated as

$$P_I = \frac{P_{CDMA}}{B} \times 30kHz \times N_{Users}$$

The interference is seen to decrease as the bandwidth increases. Further, the fade margin decreases as B increases and therefore P_{CDMA} can be reduced.

The result is clear - increasing B decreases the interference, thereby allowing more CDMA users to overlay.

For example, in B-CDMA, if B=10MHz and $P_{CDMA} = P_{AMPS}/10$, the signal to interference ratio in P_{AMPS}/P_I is proportional to

$$\frac{P_{AMPS}}{P_I} \sim \frac{10(330)}{N_{Users}}$$

If the minimum acceptable AMPS signal-to-interference ratio is about 17dB, the number of CDMA users in a sector is approximately $N_{users} = 66$. Using voice activity detection, this number becomes 132. For a 3-sector antenna, approximately 400 users can coexist with the original 48 AMPS users, without increasing the blocking probability.

The above example is for illustrative purposes only. A detailed mathematical treatment is provided in Appendix B.

2.0 COMPARISON OF B-CDMA CAPACITY IN THE CELLULAR AND PCS FREQUENCY BANDS

2.1 Broadband CDMA (B-CDMA) In The Cellular Band

Figure 2.1 shows the variation of the capacity of a B-CDMA system as a function of data rate. It is assumed that the AMPS or TDMA system uses a 3-sector antenna and that the B-CDMA system uses a 6-sector antenna. The chip rate is 8Mchips/s and the transmission bandwidth is 10MHz.

Results are presented for two cases: with an overlay, assuming all cells are fully loaded with the maximum number of AMPS and/or TDMA users; and with no overlay, i.e., the transition is complete and B-CDMA users alone occupy the spectrum.

If the B-CDMA system shared the 3-sector antenna with the AMPS/TDMA system, the capacity of the B-CDMA system would be halved.

2.2 Broadband CDMA in the PCS Band

Figure 2.2 shows the variation of the capacity of a B-CDMA system as a function of data rate in the PCS band. Three curves are shown, each assuming an omnidirectional antenna in the base station. The chip rate is 12Mchips/s and the transmission bandwidth is 15MHz.

The top curve assumes no microwave users. If additional antenna sectors are employed, the number of B-CDMA users/cell increase approximately proportionally.

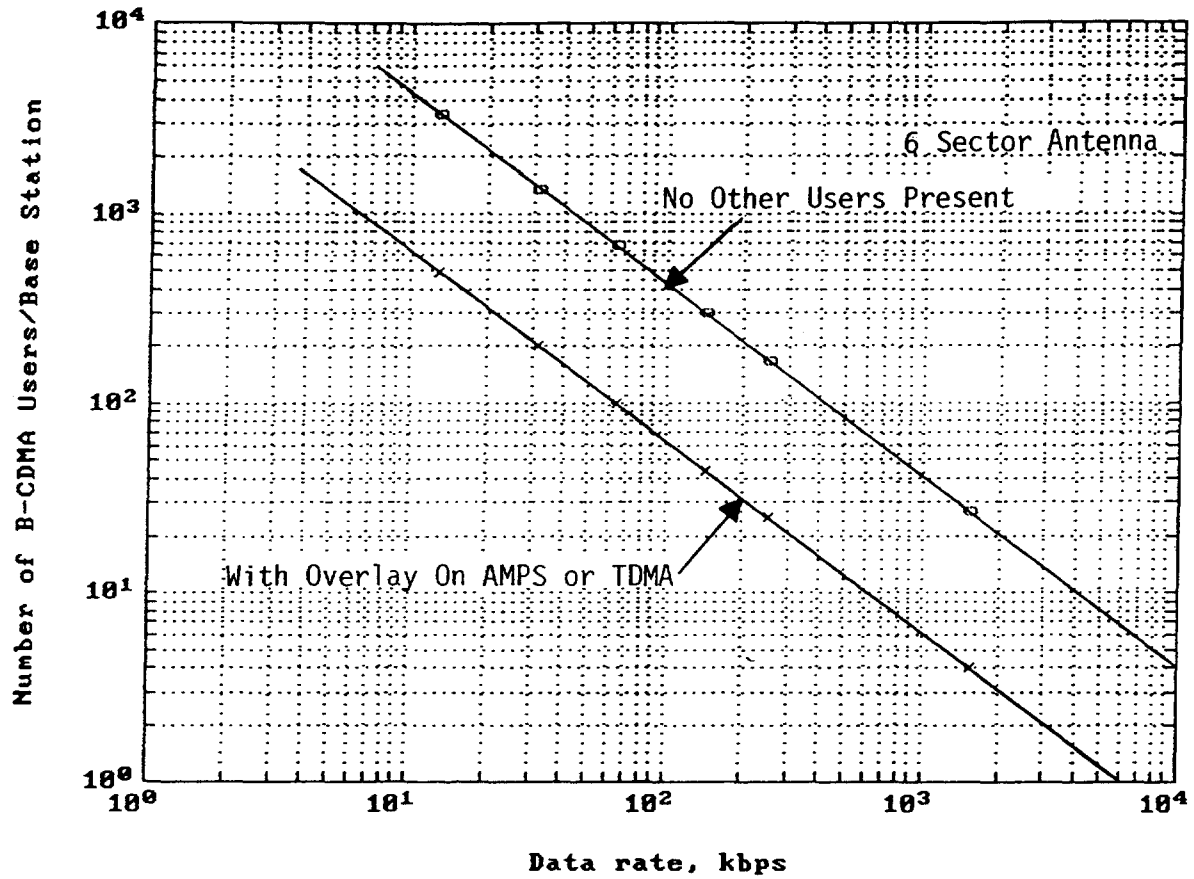
The next two curves represent a PCS overlay when microwave users are present. Note that the capacity in an urban area is significantly greater than in a suburban area since, in the urban area there is increased shielding between the PCS user and the microwave receiver.

2.3 Comparison of B-CDMA Capacity in the PcS and Cellular Bands

In order to compare the capacity of the PCS and Cellular systems, one should first note that the radius of a typical cellular cell is approximately 5000 feet while the radius of a PCS microcell is about 1000 feet. Thus the ratio of the areas serviced by a base station varies by about 25 to 1. Figures 2.1 and 2.2 compare capacity on the basis of Users/Base station, while Table 2.1 compares the PCS and cellular systems on the basis of Users/Sq. mile. Note that the number of PCS Users/Sq. mile can greatly exceed the number of Cellular Users/Sq. mile.

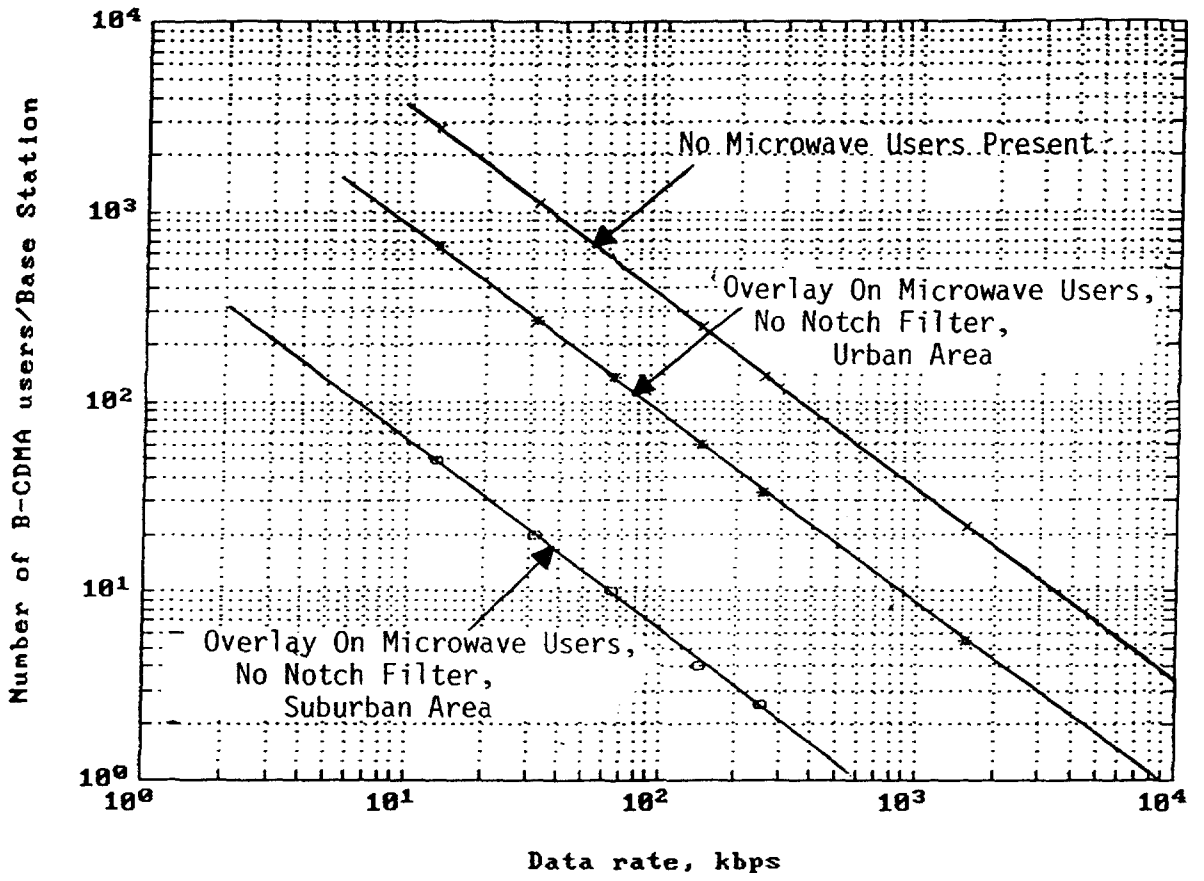
Data Rate, kb/s	Cellular Overlay Users/Sq. Mile		PCS Overlay Users/Sq. Mile		
	No AMPS/TDMA Users Present	AMPS/TDMA Users Present	No Microwave Users Users Present	Microwave Users Urban	Suburban
13	1,060	158	22,152	5,296	392
32	430	64	9,000	2,152	160
64	215	31	4,496	1,080	80
144	95	14	1,992	480	32
256	53	8	1,072	264	16
1,544	8	1	176	40	0

TABLE 2.1: COMPARISON OF CELLULAR AND PCS B-CDMA USERS



Number of B-CDMA Users in the Cellular Band

FIGURE 2.1



Number of B-CDMA Users in the PCS Band

FIGURE 2.2

3.0 CONCLUSIONS

The above study shows that B-CDMA should be employed in both cellular and PcS bands in order to maximize capacity, provide high quality voice (no delays) and high data rates (up to T1).

It is further shown that through the use of microcells in the PCS band, the capacity of a PCS system, as measured in users/sq. mile, greatly exceeds the number of users/sq. mile achievable in the cellular band.

APPENDIX D

THE COMMISSION SHOULD ADOPT AN OPEN ENTRY LICENSING MECHANISM TO PERMIT ALL QUALIFIED APPLICANTS AN OPPORTUNITY TO PARTICIPATE IN PCS

APPENDIX D

InterDigital proposes that the Commission adopt an "open-entry partnership" scheme that, for example, could impose a fee of $30-50 million[1/] to become a general partner. Companies of this size would of necessity bring to the partnership the management and organizational skills necessary to manage and organize a nationwide system. It is reasonable to assume that each of the three nationwide partnerships could attract four to five general partners.[2/] Also the number of general partners need not be limited, merely balanced. This model capitalizes the partnership at $150-250 million on day one. The limited partners could be allowed to join at a lesser fee, perhaps at $1 million each. The number of limited partners should also not be limited, except that a minimum number should be required.

All entry fees should be retained by the partnership.[3/] With a large capital base contributed by the general partners, limited partners will have little trouble finding capital sources to enable even the smallest entrepreneur to join one of the partnerships.

1/ The exact amount of the fee for a general partnership should be high enough to limit the participation to large, well-funded and managed companies.

2/ Once the number of general partners reaches four the Commission could allow foreign entities to join a partnership and not violate Commission rules pertaining to the percentage of foreign ownership of radio licenses. This would attract more capital into the U.S. PCS marketplace.

3/ The retention of all entry fees is necessary to build up a large enough capital pool to support relocation costs of the fixed microwave users. Once the partnerships are operating systems and generating revenue, a spectrum use fee could be levied on an annual basis to compensate the government for use of the spectrum.

Participation of limited partners would be analyzed based on the financing sources, the viability of the specific market, the specific service to be provided, and on the overall viability of and support from the partnership. In this way, the capital market will provide a natural limit on the number of limited partners available to each partnership.

The partnerships would have many roles. They will build out the top markets,[4/] establish technology standards, and provide a myriad of support elements. In this respect, the partnerships would select a technology standard for the nationwide systems and provide economies of scale in purchasing, construction, legal/regulatory support, and marketing to name a few of the partnership support elements. The main contribution of the partnership may, in fact, be the financial resources to relocate fixed microwave users in the partnership markets.

The relocation of fixed microwave users in the 1850-1990 MHz band will be one of the main obstacles to the viability of PCS. It will also be one of the major delaying factors in ubiquitous provision of PCS. However, by retaining all capital in the partnership, sufficient resources would be available to relocate the existing microwave users in a short period of time.

With such a large initial capitalization, the source of funds to relocate fixed microwave users would be readily available.

[4/] The Commission could decide to allow the three partnerships to build out only the top ten to fifteen markets and reserve the rest for the limited partners.

Also, given that there would be three separate pools of capital, the Commission could direct the three partnerships to share the costs of relocation in each market. The same situation would occur in the next tier served by franchisees of the partnership. If all three are building systems, then they all share. Whichever partnership elects to build out by franchise, the other two will have a limited time to elect to join in the relocation cost or be restricted from operating in that market for a fixed period of time. In this manner, equitable sharing of the cost of relocation will be accomplished across the nation.

Limited partners would be granted pre-emptive rights to be a franchisee of the partnership in selected markets. As noted above, the Commission could decide to grant the partnership, as a whole, the first right to construct under the nationwide license in the top ten to fifteen markets and require the partnership to franchise the rest of the country with pre-emptive rights to become franchisees going to the limited partners.

In the event of a conflict among limited partners in the same partnership over the same market, several forces would come into play to ensure speedy resolution. The very existence of two other PCS licensees in the same market and the competitive threat from the other competition: cellular, E-SMR and various LEO and GEO satellite-based alternatives would provide market-based stimulus to reach agreement. If agreement could not be reached, the resolution would be simple; either a settlement among the limited partners or

an internal lottery. Whatever the terms of the settlement, rapid delivery of service will be the result.

Also, those markets not contended for by limited partners could be opened to outside franchisees. The Commission could set a date by when the limited partners pre-emptive rights lapse. After a reasonable time (perhaps by the time the first top tier market is constructed) the Commission could require the three partnerships to accept franchisee requests from entities outside the franchise. This would ensure rapid deployment throughout the nation especially in non-urban areas. The pace of the deployment in this case would be controlled, not be the three licensees, but by the demand from the marketplace.

The process of establishing the three consortiums generally would be left to the Commission. As each general partner application is received, the Commission would assign the applicant to one of the three partnerships. In assigning applicants to partnerships, the Commission would strive to form a balanced group based on the size, expertise, and other characteristics of the applicants. It is assumed some companies not normally associated with the telecommunications field would apply under this licensing structure. The Commission should recognize that infusion of capital and expertise from outside the field could be a very healthy prospect for the telecommunications industry. Finally, if there was an imbalance in the receipt of general partnership applications, i.e., not divisible by three, then the Commission would conduct a simple lottery to eliminate the imbalance.

Once the three partnerships are formed, the Commission would begin accepting limited partnership applications. Again, the Commission would seek to balance the allocations and assign the limited partners to one of the three partnerships.

The advantages and benefits of an open-entry partnership process are apparent. There would be no losers. All serious participants would be allowed to participate as franchisees. The top markets would be built-out by the partnership, the next tier by the limited partners as franchisees, and finally all non-franchised areas would be available for outside franchising. Niche market franchises could be allowed at the discretion of the partnerships.

Finally, the Commission could also dispose of one of the most difficult regulatory issues facing PCS licensing: what to do with the Pioneer Preference? The Commission could simply award each preference holder a pre-emptive right to be a franchisee of a partnership. The pre-emptive right would place the preference holder on a par with a limited partner, i.e., the pre-emptive right would not cover a top market.

This plan appears to be a fair and reasonable approach to awarding preferences particularly in light of the Commission's recognition that the potential litigation aftermath of the PCS Pioneer Preference decision could render the preference worthless if the issue is tied up in court beyond the time of PCS licensing. Moreover, under this scheme, the Commission could expand the number of preferences granted without disrupting the overall licensing structure of PCS.

This all-inclusive licensing model satisfies all stated objectives of the FCC in the PCS proceeding and widens the scope of service providers to all qualified applicants. The FCC identified four objectives which it would attempt to optimize and balance in formulating the spectrum and a regulatory structure for PCS.[5/] These objectives are:

- Universality
- Speed of deployment
- Diversity of services
- Competitive delivery

If the FCC adopts the partnership form of open entry licensing, all four objectives are maximized and balanced. All other licensing options delay deployment. Clearly, deployment delay significantly undermines the first two goals. It is useful to recall that the combination of comparative hearings and lotteries for cellular services resulted in a nine year period to complete licensing for all the cellular MSAs and RSAs. Delay of this magnitude in licensing PCS could have serious adverse economic impact on the U.S. economy.[6/]

This form of licensing also ensures that technology standardization will move swiftly. If there are only three

---

[5/] Supra footnote 2 at para. 6.

[6/] NERA, in testimony at the PCS En Banc hearing (December 1991), estimated the regulatory delay in not deploying cellular at $86 billion. In written testimony NERA stated "the stakes here (in PCS) are roughly similar."

licensing entities involved, there will be a high degree of interoperability nationwide. At worst there would be only three different approaches. By comparison, cellular radio has already adopted three different access technologies and is considering a fourth.

The competitive delivery of services will be enhanced by adopting the partnership form of licensing. This licensing proposal addresses one of the major concerns in this PCS proceeding: should cellular carriers (and LECs) be allowed to be 2 GHz PCS licensees in their own serving territories?

The partnership form of licensing addresses all the anti-competitive concerns by permitting both cellular carriers and LECs to be involved in a large consortium which will benefit from their expertise and also by allowing them to provide directly PCS (even in their own serving territory) as a franchisee of one of the partnerships. As a franchisee, the partnership will guard against any anti-competitive behavior through normal franchise regulation and control of the franchisee. Finally, the ability to franchise both broad areas, as well as niche market segments, will permit the partnerships to be in a position to respond directly to marketplace demand and provide a diversity of services in response to that demand.

The partnership form of licensing will satisfy all four values identified by the FCC as important elements in developing a spectrum and regulatory structure for PCS. It also establishes a mechanism to promote diversity of ownership and technology

standardization in the shortest possible time and should therefore be adopted.